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Lubrication

A Technical Publication Devoted to the Selection and Use of Lubricants

THIS ISSUE

Lubrication of Mechanical Coal Burning Equipment

Pulverized Coal Machinery and The Mechanical Stoker

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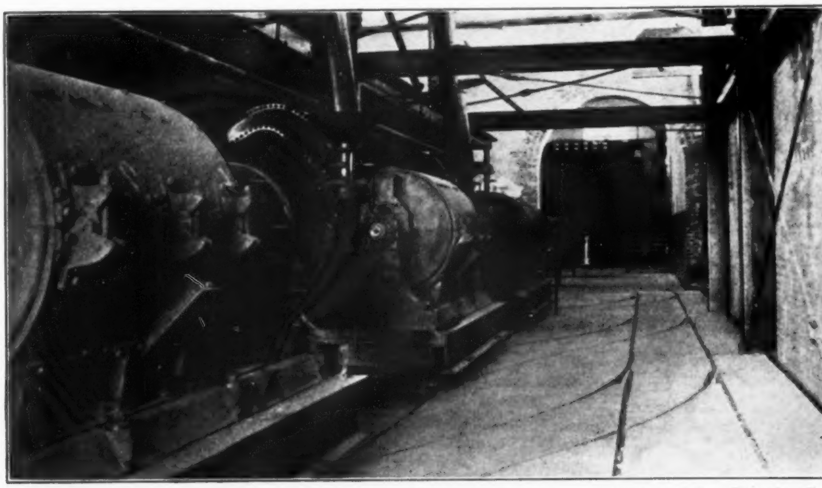


Courtesy of Aero Pulverizer Co.

Fig. 1—View of a typical pulverized coal installation wherein the units are equipped for movement over tracks according to the boilers to be served.

Lubrication of Mechanical Coal Burning Equipment

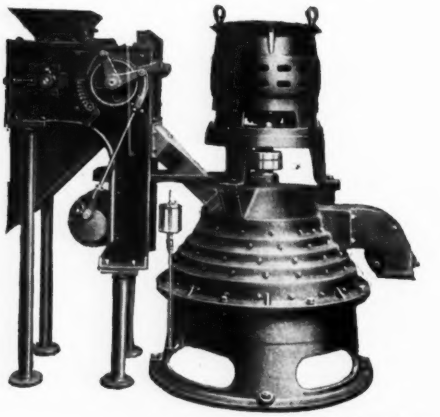
Part I

PULVERIZED COAL MACHINERY

PULVERIZED coal as a means of steam generation has attained remarkable success and popularity in the field of power plant engineering during the past few years. In company with the automatic stoker, in fact, it may well be stated, that the pulverizer with its accessory equipment, has practically superseded hand firing of coals. Especially is this true in the modern stationary power plant. To what degree such equipment will be extended to industrial heating furnaces, or the steam locomotive, is difficult to anticipate. The fact remains, the possibilities for increasing economy and boiler efficiency are so marked that we can expect every effort from stoker and pulverized fuel engineers in the promotion and perfection of their products. Already the latter have developed unit pulverizer systems which

are giving very satisfactory service in connection with the firing of oil stills in the petroleum industry, in metallurgical work, and for the generation of steam in locomotive service.

Fuel conservation is one of the most important factors in modern boiler plant operation.



Courtesy of Grindle Fuel Equipment Co.

Fig. 2—A multi-stage unit pulverizer and belt feeder with magnetic separator. The rotor is fitted with S. K. F. self-aligning ball bearings. Other pulverizer bearings are oil cup lubricated, the feeder bearings being designed for pressure grease lubrication.

It is, in fact, the keynote of efficient combustion, for boiler efficiency is directly dependent upon the amount of fuel burned in the evaporation of water into steam. If we can reduce potential heat losses due to incomplete combustion, it is logical to expect that our rate of evaporation per pound of fuel will be increased. Solid fuels are, in general, more susceptible to wasteful handling and firing than either liquid or gaseous fuels. Unless properly fired under carefully regulated draft conditions, there will, furthermore, be marked possibility of the occurrence of more or less incomplete combustion, with corresponding waste via the ash-pit or up the stack. The development of automatic means to improve these conditions has, therefore, been a most logical step in keeping with the advancement of the science of steam engineering.

It will, therefore, be of interest to look into the principles of operation, and lubrication requirements of pulverized fuel equipment which today shares honors with the stoker in the automatic firing of coal.

SYSTEMS INVOLVED

The firing of pulverized coal involves the use of either the bin or storage system, or the unit system, wherein there is usually one pulverizer per boiler. The latter in general requires less equipment, and, from the viewpoint of lubrication, at least, is the more simple of the two. Both embody the same basic principle, i.e., the pulverization of coals to a sufficient extent to permit of firing in the form of a powder.

The Unit System

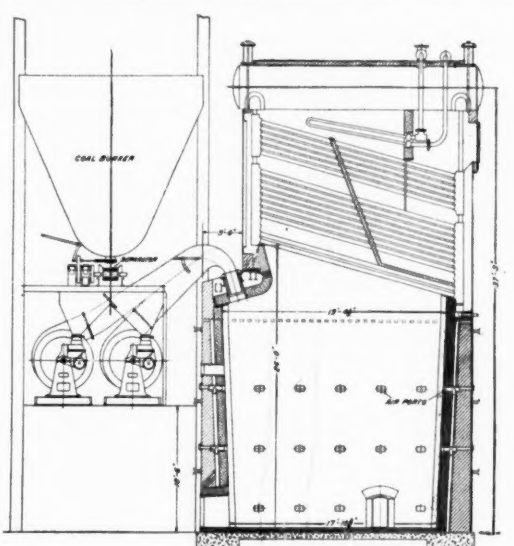
In the unit system the pulverizer is the essential piece of equipment from an operating as well as a lubricating point of view. Other apparatus involved may comprise a separator, a fan for secondary air supply, and the necessary driving motors.

The Bin System

The bin system, in turn, usually involves, in addition to the pulverizer, such machinery as a dryer, dryer fan, conveyor, exhaust fan for use in connection with the pulverizer, a cyclone separator or dust collector, oftentimes an air compressor, a coal feeder blower and the necessary driving motors. All of these contain bearings which require careful attention to lubrication.

Function of the Pulverizer

Of the above equipment, the pulverizer being of outstanding importance, will require a certain amount of discussion and explanation. Essentially it consists of a horizontal or vertical rotating and pulverizing element mounted on a



Courtesy of Erie City Iron Works

Fig. 3—View of a pulverized coal burning installation showing relation of equipment to boiler, etc. Bearings of this pulverizer are ring oiled.

shaft, the whole being contained within a suitable housing. According to the design the pulverizing element or rotor may be constructed to perform its intended function in one or more stages, frequently being fitted at one end with a suitable fan which draws in sufficient air to

carry the coal through the system, and aid in bringing about combustion. Actual breaking up or pulverization of the coal is accomplished by swing hammers, rings, tubes or suitable rolls in conjunction with the crushing surface of the housing.

In such a system the pulverizer is, of course, subjected to the most severe service conditions and therefore may involve more potential lubricating problems. Coal dust is continually present, sulphurous products which will tend to react with water to form corrosive acids may have to be handled, and dampness is frequently a problem. All of these are detriments to operation, in that the least failure in a lubricating system may cause scoring or corrosion of the rotor bearings, or such other bearings as are involved in other equipment. Such conditions will lead to more or less solid friction due to faulty lubricating films between the wearing elements in question, ultimately causing an increase in power consumption.

IMPORTANCE OF LUBRICATION

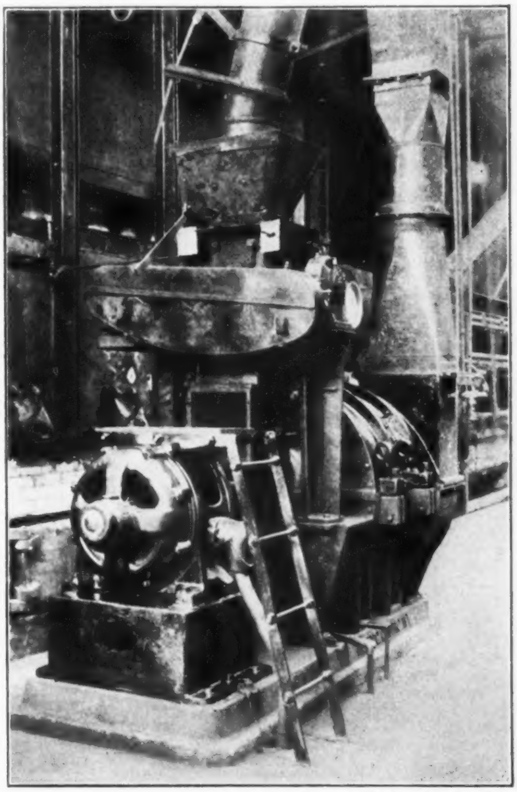
Lubrication of pulverized fuel equipment is, therefore, essentially a matter of reducing the power requirements of the various motor, fan and pulverizer bearings. The fact that the primary purpose in burning pulverized coal is to increase steam poundage per ton of coal by reducing waste of heat units through incomplete combustion, renders it equally important to extend our efforts to the wearing elements of all equipment involved, to reduce the amount of power consumed. Failure in either case would, to a more or less extent, discount any potential advantages which might accrue from the other.

Equipment Involved

With the unit type of pulverizers, as noted, equipment will be far more simple than where a bin or storage system is used. As a rule, the primary parts requiring lubrication will consist of the bearings of pulverizers, motors, air fans and conveyors. Anti-friction bearings are extensively used to carry the main shafting of rotary pulverizing and fan elements. Thereby are these parts effectively protected against the entry of abrasive coal dust, dampness or perhaps metallic particles.

Lubricating Requirements

The functions of lubricants on practically all wearing elements involved in pulverized coal burning equipment is twofold: (A) to lubricate, that is to reduce metallic or solid friction to a minimum by the maintenance of a film of fluid oil between the bearing surfaces or surfaces in motion with respect to one another; and (B) to protect these surfaces from scoring or abrasion, by preventing entry of foreign matter such as coal dust or dirt. Resultant friction, or the braking element which determines the amount of power required to operate any part of the machinery is reduced by substituting the fluid friction of oil for the solid friction which would otherwise occur between any two solid surfaces in motion with respect to each other. Fluid friction is far lower than solid friction, therefore, continued operation at high speeds is possible, provided of course, that this film of oil is maintained in unbroken condition by periodic application of fresh lubricant. In this way temperatures are also kept within safe limits.



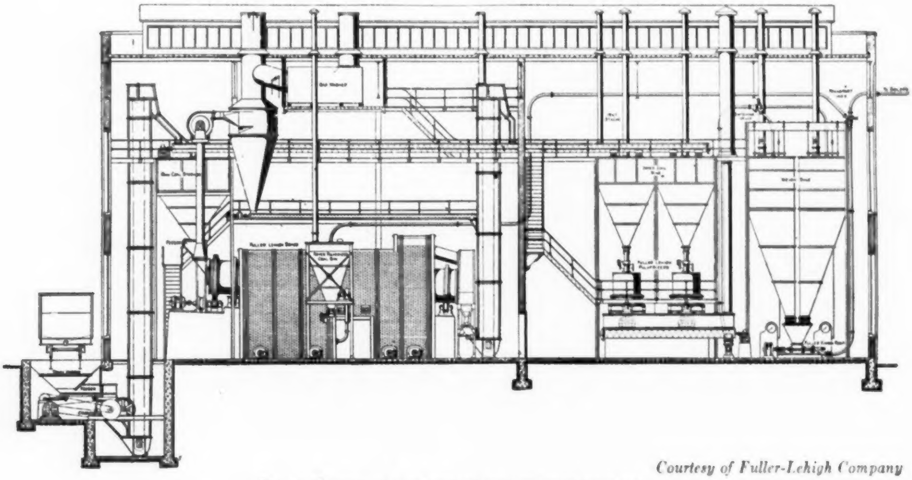
Courtesy of Furnace Engineering Co., Inc.

Fig. 4—A unit type pulverizer installation showing driving motor, and feed mechanism. Ball bearings are used on main bearings. Worm gearing runs in an oil bath.

In turn by selecting lubricants of such body or viscosity as to remain in bearing clearance spaces for a reasonable length of time, not only will economy of lubrication be attained, but also will entry of foreign abrasive matter via any exposed bearing ends be prevented.

The fact that lubrication plays so important a part in the attainment of economical pulverized fuel equipment operation requires a rather

detailed discussion of bearings and their constructional details. It can be appreciated that unless we have a knowledge of the lubricating requirements of various types of bearings, it would be a difficult matter to determine correctly the proper grade of oil or grease to use. In addition the types of lubricating systems must also be understood. Both oil and grease in their proper consistencies are ideal lubricants; they must, however, be adapted to the systems of lubrication and the construction of the bearings. In many cases either one would give satisfactory service; unsealed bearing construction, the prevalence of temperature fluctuations or abnormal clearances, however, might markedly influence resultant economy. Therefore all these conditions should be considered when selecting such lubricants.



Courtesy of Fuller-Lehigh Company

Fig. 5—Layout of a pulverized coal preparation plant.

Courtesy of American Pulverizer Co.

Fig. 6—Exterior view of a ring type coal crusher. Note in particular the main bearings which are designed for combined grease and oil lubrication by suitable compression grease, and sight feed oil cups.

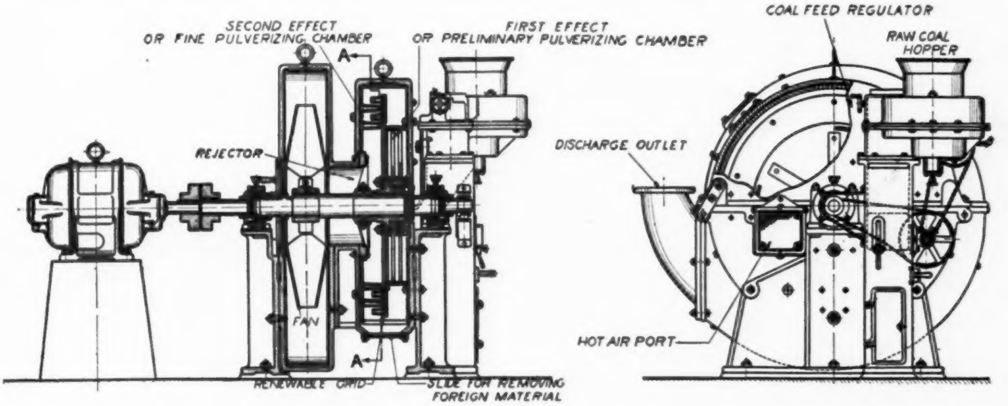
Ring Oilers

In such devices oil is continually carried to the bearing surfaces from a reservoir which is part of the bearing housing, by means of a ring which is suspended from the shaft, dipping into the oil to a more or less extent according to the level at which the oil is carried. In order to insure effective lubrication by a ring oiler it is important that the reservoir be of adequate capacity to give the oil ample opportunity to rest, thereby making possible not only the settling out of sediment and other foreign matter, but also cooling to the requisite degree. As a rule the only way in which the oil in such a system is kept at the proper temperature is by radiation of heat from the exterior surfaces of the reservoir or well.

In event of this latter being of apparently insufficient capacity, at times it is possible to overcome this by fitting an auxiliary reservoir below the one in question. One way in which this can be done is to tap a short length of pipe into the lower part of the bearing, plugging the bottom end with a cap. Such a device has an added advantage in that it also acts as a dirt collector.

It is apparent that oil which is carried to the top of a ring-oiled bearing must be taken care of and returned to the reservoir as rapidly as

it is delivered by the ring. If this is not possible, oil will tend to accumulate in the upper part of the housing to ultimately be forced out through the ends of the bearings.



Courtesy of Riley Stoker Corp.

Fig. 7—Detail view of the Atritor unit system for pulverized coal. The main shaft of this machine is equipped with roller bearings. The Dot system of high pressure grease lubrication is employed on all bearings.

The same condition may arise if the oil is carried too high in the well, or if the ring rotates at too high a speed. This will cause a splashing and churning of the oil.

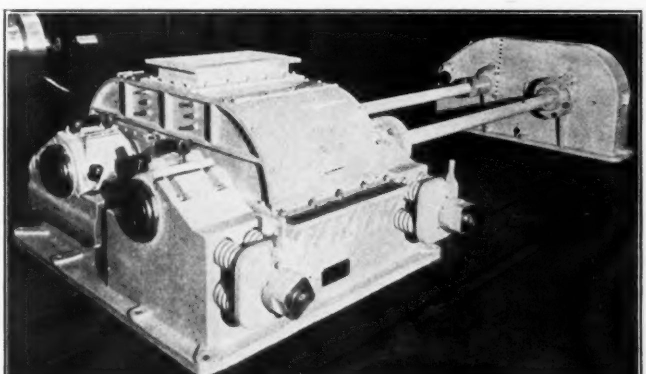
Oil Characteristics

To best effect lubrication by means of ring oilers, under normal temperature conditions it is essential to use a high grade straight mineral oil of approximately 150 to 200 sec. Saybolt at 100°F. In determining upon the viscosity of such an oil, the bearing construction should be investigated; oftentimes if oil returns are too small they may become clogged, causing heavier oils to overflow. By virtue of the fact that certain equipment may frequently be called upon to function under abnormally low temperatures, an oil with a low cold test should be chosen wherever possible. If this latter approximates zero degrees Fahr. the oil will generally function satisfactorily. On the other hand, higher temperatures will oftentimes require additional viscosity to resist the thinning down action of heat. Under such conditions, an oil of from 300 to 400 seconds viscosity or even higher may be advisable.

Ball and Roller Bearings

Anti-friction bearings of the ball and roller type have been extensively adopted by pulverizer equipment builders where certain requirements such as reduction in the amount of attention from a lubricating point of view and positiveness of action must be observed. Ball bearings can be lubricated either with oil or light grease according to the design of the bearing housings. Roller bearings can be similarly lubricated though the type and construction of the rollers must be considered in addition. The customary housing design affords ideal protection against the entry of contaminating foreign matter, and the least amount of oil or grease is required for refilling.

From a constructional point of view anti-friction bearings involve rolling contact as compared with plain bearings wherein sliding contact occurs. In ball bearings, this rolling contact is that of a theoretical point over a given surface. Roller bearings, however, involve theoretical line contact between the journal or shaft element and the outer raceway.



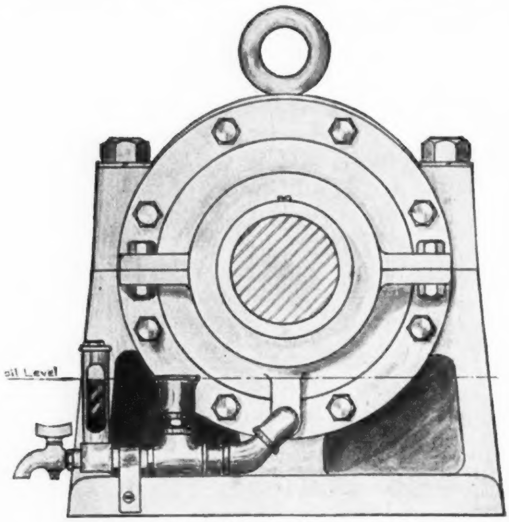
Courtesy of Bethlehem Steel Co.

Fig. 8—View of a roll type coal crusher. Rolls are motor driven through herringbone gears. Crushing pressure is maintained by spring tension.

Purpose of Lubrication

The purpose of lubrication is to facilitate as easy rolling as possible. To enable this, how-

ever, all the surfaces (which are of a highly polished nature) must be in as perfect condition as practicable. The lubricant must therefore serve the dual purpose of both lubricating, and protecting these surfaces against rusting, corrosion, pitting or abnormal wear. Minimum clearance of course is an aid to proper functioning of such bearings, for the occurrence of any play between the component parts would tend to set up a certain amount of pounding which would be detrimental to effective operation. In other words, all motion must be as nearly akin to perfect rolling as possible.



Courtesy of Aero Pulverizer Co. and S. K. F. Industries, Inc.

Fig. 9—End view of a unit pulverizer bearing equipped with self-aligning roller bearings. Note gage glass, overflow and drain cock located at lower part of bearing. Oil level is shown by dotted line.

Viscosity Requirements

As a general rule as light a lubricant should be used as can be successfully retained in such a bearing commensurate, of course, with the temperatures and pressures involved. Usually an oil with a viscosity of from 100 to 200 seconds Saybolt at 100 degrees Fahr., will be best.

To reduce the possibility of the development of abnormal internal friction within the lubricant, it is generally advisable to pay careful attention to the oil level. Certain authorities contend that submergence of approximately one-half to three quarters of the lowest ball will be sufficient. In this connection it is important to remember that contrary to the principles of plain bearing lubrication, the oil in a ball or roller bearing plays no part as a coolant. Therefore volume is a detriment rather than an advantage.

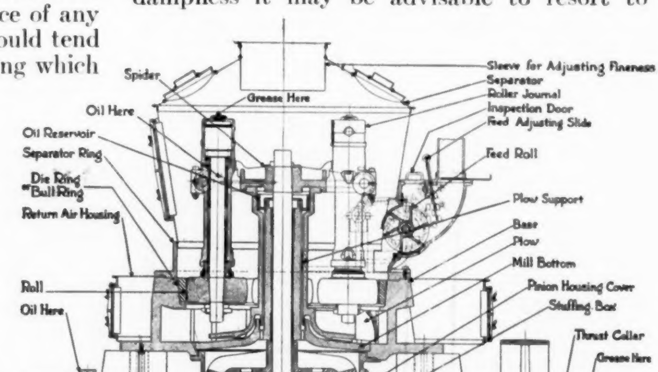
Roller Bearings

Roller bearing lubrication by means of oil is subject to much the same conditions as stated in connection with ball bearings. Where end thrust may develop to an appreciable extent, however, due to difficulty in keeping the rollers in alignment, or where pressures or temperatures may be high it is the opinion of certain authorities that it will be conducive to better lubrication if somewhat heavier oils are used.

Under such conditions the use of straight mineral lubricating oils of as high as 750 seconds Saybolt viscosity at 100 degrees Fahr. are advocated. Even mineral cylinder oils of a high degree of purity may be necessary under conditions of extremely high duty, pressure or temperature.

The selection of heavier oils for roller bearing lubrication, however, should be carried out with the utmost care for it is very possible to over-estimate the conditions of operation with the result that an excess of internal friction may be developed. As a rule careful observation of bearing temperatures, and cooperation with the builder and oil industry will insure satisfactory results.

Wherever there is possibility of oil leakage, however, or under conditions of dust, dirt or dampness it may be advisable to resort to grease as the lubricant. Greases furnish better seals against the entry of dust, dirt and moisture thereby serving to protect the polished surfaces of the bearing elements in a very satisfactory manner. Grease also can be very



Courtesy of International Combustion Engineering Corp.

Fig. 10—Sectional view of a vertical roll type pulverizer showing essential parts. Note in particular the provisions for oil and grease lubrication.

much more effectively retained in a non-oil-tight housing; on the other hand, dirt or grit that finds its way into a grease lubricated bearing, has no means of settling out, but is frequently held in suspension, being carried back into the bearing repeatedly.

As a general rule soap-thickened oils which are comparatively fluid in consistency will meet average operating conditions where the lubricant must readily cover the entire surfaces of the balls or rollers and not tend to channel in the housings or raceways, as might occur with more viscous products of this nature which would have less of a penetrative ability. On the other hand under conditions of extra high temperature, it might be necessary to resort to greases of greater body to withstand the thinning-out effects of heat, and prevent the consequent entry of dust, dirt, or other contaminating foreign matter.

Part II

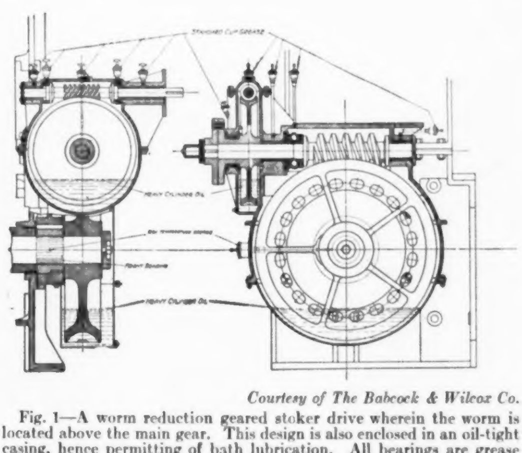
THE MECHANICAL STOKER

Where, for any reason it is not deemed necessary or advisable to fire coal in pulverized form, and yet automatic handling is desired, the mechanical stoker in one of its several types is a practical and efficient means of overcoming the difficulties of hand firing.

According to the principle involved, or the means by which the coal is delivered to the furnace, mechanical stokers are known respectively as

(a) the overfeed
(b) the underfeed and
(c) the traveling or chain grate type.

The mechanism of the modern stoker is relatively simple in design, the driving unit being the essential part requiring lubrication. Individual manufacturers, however, employ



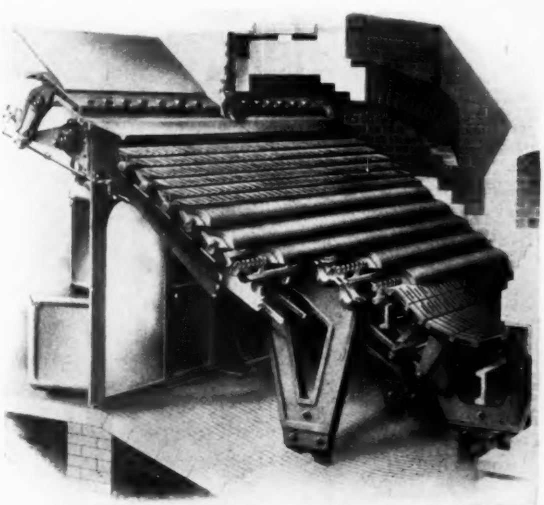
Courtesy of The Babcock & Wilcox Co.

Fig. 1—A worm reduction geared stoker drive wherein the worm is located above the main gear. This design is also enclosed in an oil-tight casing, hence permitting of bath lubrication. All bearings are grease lubricated as indicated.

various adaptations or types of drives according to the operating requirements of their stokers. In studying stoker lubrication we must, as a result, look into the several designs or basic types in use today, inasmuch as lubrication will be materially contingent thereupon.

TYPES OF STOKERS

In the *Overfeed Stoker* coal is fed in at either the sides or front end of the furnace through a



Courtesy of Westinghouse Electric & Mfg. Co.

Fig. 2—Sectional view in perspective, of a mechanical stoker of the overfeed type. Details of grate construction are clearly shown.

hopper or magazine, being distributed along the top of an inclined set of grates.

Where front feed is involved the grates slope towards the rear of the furnace, being set in one uniform plane. In the side feed furnace there are two sets of grates, each set sloping towards the center, making an angle or V at their lowest point.

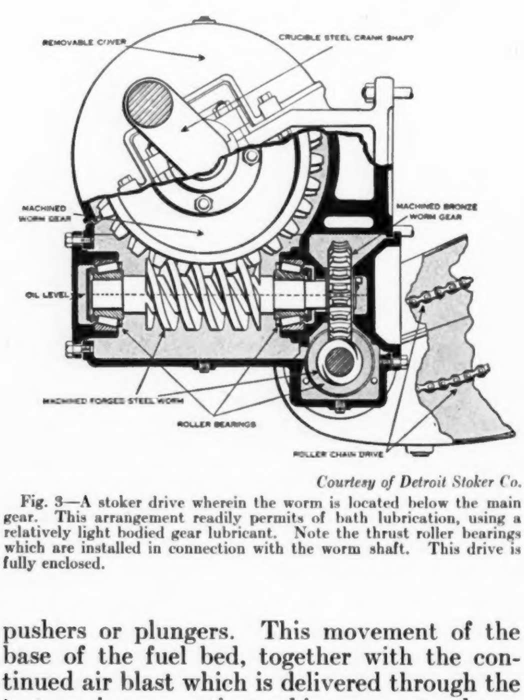
In an overfeed stoker installation certain of the grates move backward and forward with respect to each other, being actuated by kicker or rocking bars. This motion carries the fuel

down the grates to the rear or center. All this time combustion is taking place, coking and the burning of volatile gases occurring while the coal is on the upper parts of the grate. When the coal has been carried to the clinker crusher or dumping device at the bottom of the grate or grates, it should have been completely burned and should then be ready for discharge as ash.

Overfeed stokers are adaptable to the firing of coking varieties of coal due to the motion of their grates which keeps the fuel bed porous and broken up, thus preventing caking or the formation of clinkers.

Underfeed Stokers involve the introduction of fresh coal beneath the fuel bed by means of steam or electric driven rams or plungers. The coal is usually delivered through a gravity feed hopper to the several retorts in which these rams or plungers operate. Essentially these retorts are individual primary combustion chambers, the sides being either stationary or subject to reciprocating motion. These sides also serve to carry the tuyeres or air grates, the latter consisting usually of a number of superimposed perforated plates.

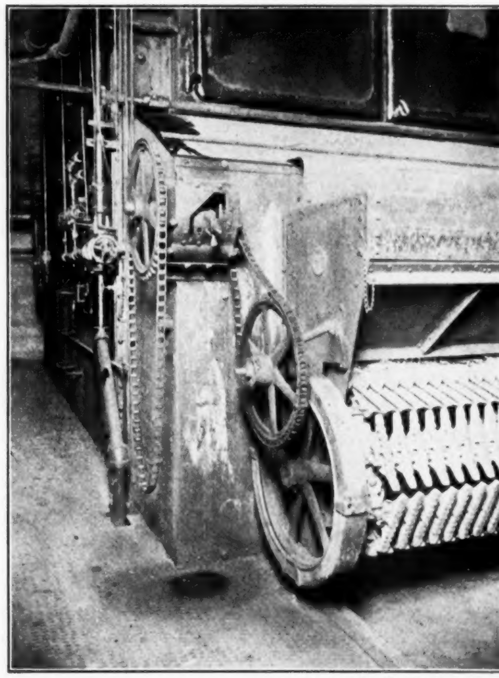
As fresh coal is fed into the retorts it is gradually forced underneath the fuel bed by the action of either the plunger alone or a number of automatic auxiliary distributing



Courtesy of Detroit Stoker Co.

Fig. 3—A stoker drive wherein the worm is located below the main gear. This arrangement readily permits of bath lubrication, using a relatively light bodied gear lubricant. Note the thrust roller bearings which are installed in connection with the worm shaft. This drive is fully enclosed.

pushers or plungers. This movement of the base of the fuel bed, together with the continued air blast which is delivered through the tuyeres, insures against caking or any tendency towards dirty fires. The volatile gases are driven off as the fresh coal becomes hotter and hotter through its proximity to the fuel bed above, being burned as they pass through this heated area; the green coal meanwhile becomes gradually coked and ultimately burned completely.



Courtesy of Burke Engineering Co.

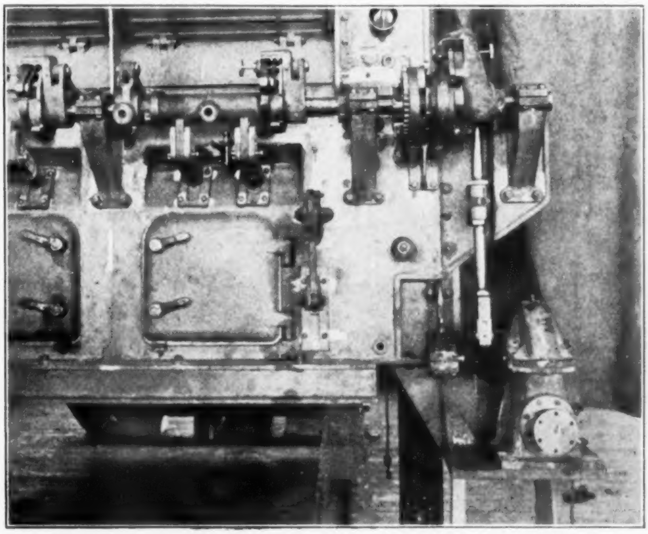
Fig. 4—Detail showing direct spur gear drive, grate speed regulator and application to power drive. Where chains are exposed careful application of lubricants is necessary as mentioned in test. Alemite high pressure grease lubrication is employed on main bearings of this stoker.

The *Chain Grate* or *Traveling Stoker* involves an endless chain which passes over suitable sprockets at the front and rear of the furnace, the meshed links or bars of this chain serving as the grate or fuel bed. This chain is in motion continuously, passing round and round through the furnace, taking fresh fuel at one end of the furnace and discharging the residual ash at the other, as the chain turns over the sprockets. The necessary sprockets are fastened to suitable shafts which are part of the base frame of the stoker. Either the front or rear sprocket can be used as the driving element by suitable connection to a worm reduction gear mechanism, which in turn may be either driven by steam or electric power.

Coal is fed by gravity to the chain grate stoker in much the same manner as to the other types mentioned above; usually a suitable hopper is installed for this purpose at the front end of the furnace. The necessary air for combustion is delivered through the chain grate via either one or more distributing compartments below the top grate.

STOKER DRIVES

In order to manipulate the grates of the overfeed stoker, operate the plungers and rams of the underfeed machine, run the chain grate at the desired speed, and turn the clinker grinder, it is essential to use some form of reduction geared power unit. This is commonly either a small vertical reciprocating steam engine, a turbine or an electric motor.



Courtesy of McClave-Brooks Co.

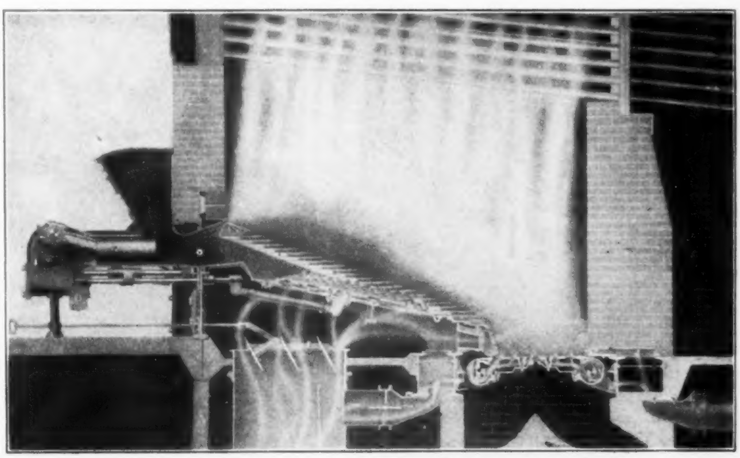
Fig. 5—Front view of a mechanical stoker showing worm reduction gearing enclosed in an oil-tight casing, the mechanical timer with four speed reduction, and the kicker bar operating mechanism with driving rod.

The several types of stokers on the market vary considerably in their methods of handling fuels just as they vary in regard to their driving mechanisms.

In the overfeed stoker the feature of operation is the rocking or reciprocating motion to which the grates are subjected. This is brought about by means of a kicker bar or rocker which receives its reciprocating motion from the driving unit through a crank, eccentric connection, or a series of toggle levers.

The underfeed stoker in general depends upon the reciprocating action of the plunger in the charging of fresh fuel and the pressure of the air blast, for the agitation of the fuel bed. Therefore, the essential operating mechanisms involved are the plunger and the coal feeding devices. The plungers and distributing rams are usually connected to the driving unit through a suitable crank shaft of heavy construction. The driving unit can also be further connected through crank, link or rod mechanisms to operate a clinker grinder if necessary, and also the reciprocating overfeed grates and retort side bars in some types of stokers. As a result a regular sequence of operation is maintained in all the necessary moving parts just as long as the driving unit is running and the proper connections are maintained.

The principal operating part in the chain grate stoker is the driving mechanism. As has already been stated this may be attached to either the front or rear sprocket shaft through suitable reduction gearing. Additional mitre gears in connection with adjustable ratchet mechanisms are also used on some front feed stoker drives for the purpose of regulating the coal feeding device. In other types a handwheel operated worm and gear device is used for the controlling of the coal feed from the hopper onto the stoker chain. The sprocket shafts are carried in pedestal bearings of suitable size and construction to meet the wearing conditions and enable the requisite lubrication.



Courtesy of Combustion Engineering Corp.

Fig. 6—Longitudinal section through a typical underfeed type of stoker. The actual relation of the fuel and fuel bed to the operating mechanisms of the stoker is clearly shown.

STOKER LUBRICATION

In every type of stoker there are therefore, certain definite details, which will require lubrication, i.e., there are the worms and gears, the miscellaneous bearings of the accessory

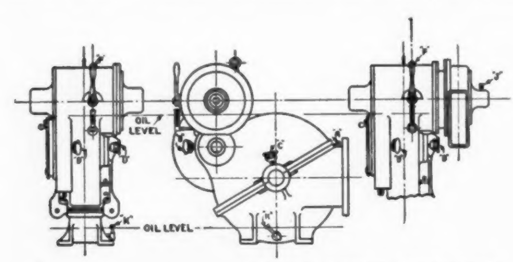
connections which serve to operate the movable grates, etc., the pedestal and other more important bearings of both chain grates and underfeed stokers and the driving engines, turbines and the electric motors. As a result, stoker lubrication can be discussed from three broad viewpoints, viz., as applying to reduction gears, bearings and steam cylinders, of the respective steam engines, steam turbines, electric motors, silent chain drives, or in certain cases, line shafting and belts. The lubrication of such equipment has been extensively dealt with in recent issues of LUBRICATION*. Therefore reference is made to those articles to avoid unnecessary repetition.

While many of the moving parts of any type of automatic stoker are exposed to a certain amount of heat, such connections as require lubrication are generally subject to far lower temperatures, although these latter may often be sufficiently high to render lubrication a serious problem. Bearings of movable grate connections as a rule will be chiefly affected in this respect. Other operating parts being outside the furnace receive only the heat of radiation from the boiler.

Steam Cylinders

Certain types of stokers may be equipped with vertical, reciprocating, enclosed crankcase steam engines, which are usually of the single acting type. As a result, a few words of detail regarding their lubrication will be of interest.

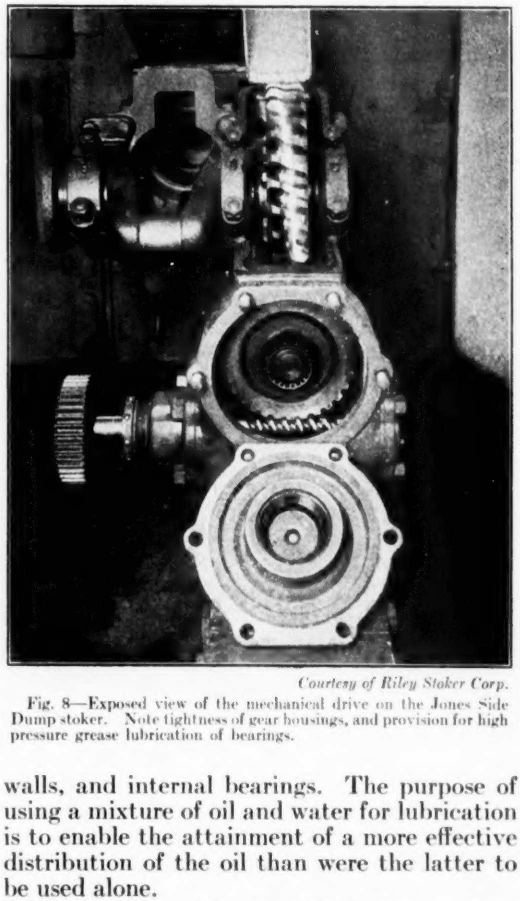
In the lubrication of these engines the design not only does not aim to prevent the entry of water but actually makes use of this latter as a carrier for the oil. During the process of lubrication the oil in the crankcase not only serves



Courtesy of American Engineering Co.

Fig. 7—Power box of the Taylor Stoker. Two sets of spur gears are contained in this type of drive, i. e., the planetary and main gears. Note oil levels for both sets of gears, the filling holes "A" and "F" respectively for adding oil to main and planetary gears; the main gear case drain "K"; and compression grease cups "C" and "D" for crankshaft and pinion bearing lubrication.

the bearings, but also the cylinder walls to a partial extent, cooperating in this latter with the oil which is fed in with the steam. To obtain effective lubrication the crankcase must be filled with water (preferably condensate) to the level of the overflow pipe. On top of this body of water is carried a $\frac{1}{8}''$ to $\frac{1}{2}''$ film or layer of specially refined lubricating oil. As the crank disc dips into this the requisite amount of lubricant is thrown to the cylinder



Courtesy of Riley Stoker Corp.

Fig. 8—Exposed view of the mechanical drive on the Jones Side Dump stoker. Note tightness of gear housings, and provision for high pressure grease lubrication of bearings.

walls, and internal bearings. The purpose of using a mixture of oil and water for lubrication is to enable the attainment of a more effective distribution of the oil than were the latter to be used alone.

Thereby, too, it is possible to bring about lubrication of both cylinders and bearings by means of one oil, and that a heavier product than would normally be used for other splash feed systems. Usually this oil should have a viscosity in the neighborhood of 100 seconds Saybolt at 210° F. Furthermore, it must separate readily from water, yet it must have sufficient adhesive ability to render it capable of clinging to the cylinder walls in the presence of water. Emulsification to a slight extent does no harm, but there is always possibility of repeated churning causing thick emulsions or "livering," especially if too much oil is used or if it has not been sufficiently carefully refined and prepared. Emulsions will frequently tend to render the lubricating system inoperative.

Main bearings of such engines are usually lubricated by sight feed oil cups or compression

*August, 1923; November, 1923; April, 1924; February, 1925; June, 1925; October, 1925.

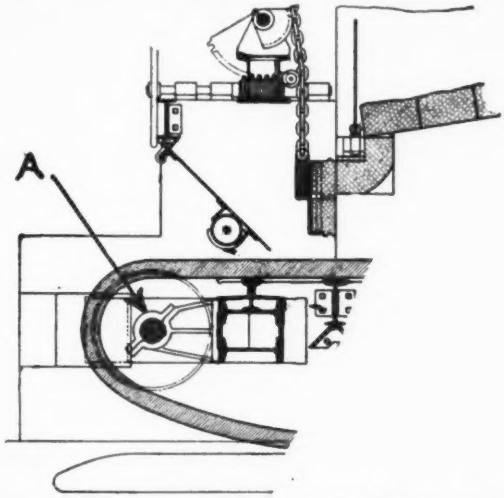
grease cups. The steam in turn is lubricated as necessary through hydrostatic or force feed oilers using oftentimes the same grade of oil as in the crankcase.

Reduction Gears

Worm and spur gears are perhaps the most important parts from the viewpoint of lubrication. According to the make of stoker, the worms may be located either above or below the main driving gears. As a result, their lubrication requires consideration from two angles. Stokers normally run at low speeds due to the gradual rate at which the coal must be fed. As a result large speed reductions are used especially where the prime mover is a turbine or an electric motor. The selection of the lubricant for a stoker worm drive should be based primarily upon the type of gear casing installed. In other words an oil tight casing will enable the employment of bath lubrication and the use of a lubricant of just sufficient viscosity to preclude wearing of the teeth. Where but a safety gear shield or an open or leaky case is involved, naturally we must turn to the heavier, more plastic grades of lubricants.

Worm Gear Requirements

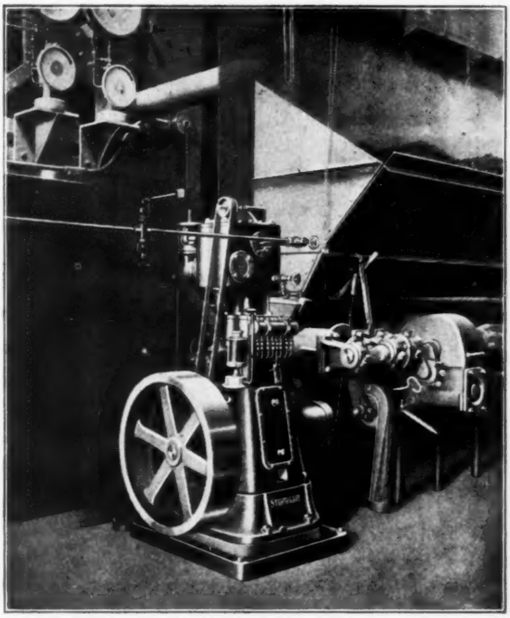
Essentially a worm gear installation will require a comparatively heavy, adhesive lubri-



Courtesy of Illinois Stoker Co.

Fig. 9—Sectional view of front of a forced draft chain grate stoker. "A" indicates front shaft bearings. When using preheated air, a high melting point lubricant must be used here to withstand the effects of heat, to insure continued lubrication of the bearings and protection of babbitted surfaces.

cant which will not wipe off the teeth when subjected to the combined sliding and rolling action of the teeth. Furthermore, in many installations the same lubricant must not only serve to lubricate the gears but also the worm shaft thrust bearings. Inasmuch as the lubricating requirements will differ considerably, in such cases it will be necessary to compromise and use a lubricant as suitable to both as possible. Usually a straight mineral product of about the consistency of steam cylinder oil will meet the conditions.



Courtesy of B. F. Sturtevant Co., Inc.

Fig. 10—A vertical type of stoker driving engine showing method of connection to the stoker proper, and the means installed for lubrication.

The location of the worm with respect to the gear is important not only from the viewpoint of selection of the grade of lubricant, but also as to the manner of lubrication. When the worm is located below the gear it should be submerged to approximately the center line of the worm shaft. This will insure the transference of sufficient lubricant to the gear teeth as they mesh with the worm.

This condition does not occur to the same extent, however, when the worm is above the gear, due to the lower surface area of the gear teeth, and the fact that the lubricant will tend to travel along the worm shaft and drip down outside the trough. Also, especially when the stoker is first started up will there be a possibility of an insufficient film of lubricant being carried by the gear teeth to the worm. To forestall these conditions, it is advisable to run the gears submerged to the full depth of their lower teeth in a bath of lubricant, and use a highly adhesive, though relatively fluid product which will stick tenaciously to the worm teeth and not drip off even where radiated heat may be relatively high.

Spur Gears

Certain stokers which are equipped with spur gearing will in general have these latter adequately enclosed in a suitable housing or power box which will enable the use of more fluid lubricants than generally advisable in a worm reduction gear installation. Especially is this true in the case of the planetary gear which

Courtesy of Westinghouse Electric and Mfg. Co.

Fig. 11—Gear train for a two-speed gear box on a multi-retort underfeed stoker. The fineness of construction requires careful selection and application of lubricants for both gears and bearings.

constitutes the first reduction. Here the lubricant must serve both the gears and bearings of their respective shafts. For such service a straight mineral oil of about 750 seconds Saybolt viscosity and 100° F. will suffice. The so-called main gears, or in other words, those which bring about a secondary reduction in speed to conform to that required at the crank shaft, are, however, frequently provided for independent lubrication. To meet the pressure, vibration and slow speeds involved a heavier lubricant capable of adhering tenaciously to gear and pinion teeth should be used. In general an oil having a viscosity of approximately 100 to 120 seconds Saybolt at 210° F. will be best.

Exposed Gearing

When gear drives are not enclosed in an oil-tight casing bath lubrication is usually precluded, and it becomes necessary to apply the lubricant by hand, in heated condition, by means of a brush. In such instances the lubricant must be of considerably higher viscosity than specified above since it must maintain a suitable film on the teeth for the usual considerable period of time which elapses between applications. Low viscosity oils or non-adhesive greases will drip off when thinned down under the higher temperatures encountered. For such gears it is therefore advisable to use a straight mineral gear lubricant of approximately 1000 Sec. viscosity Saybolt at 210 deg. F. Dirt and dust must also be considered when lubricating reduction gears of this type. Therefore, frequent attention should be given to cleaning the entire mechanism, otherwise excessive wear may occur due to the presence of abrasive material in the lubricating film on the teeth.

Bearings

Bearings in a stoker installation are internal and external in location. Internal bearings usually get little or no lubrication; in fact they are generally built with relatively high clearances, to operate without oil. The amount of motion to which they are subject is relatively slight, as is also the comparative rubbing speed. Therefore, heat conditions are really the only detriments involved.

External bearings, however, should receive careful attention. Frequently they are designed for grease lubrication, being equipped with suitable grease cups, or fittings for pressure lubrication.

Equipment of this type is advantageous in that it is usually dustproof and insures a supply of clean lubricant to the bearing surfaces. Grease also tends to work out toward the end of the bearing, thus preventing the entry of dust along the shaft. For such service a medium bodied compression cup grease free from thickeners or non-lubricating adulterants will function best.

It is also important to remember that in certain stokers the bearings of at least part of the gear shafting involved will be designed for lubrication by the same lubricant as serves the gears. This materially simplifies the problem from a labor point of view, and also insures the bearings of more positive lubrication than where periodic attention is necessary. It necessitates, however, more careful selection of the lubricant, for the requirements of both gear teeth and bearings must be adequately met. Unless pressures and temperatures are abnormal, a straight mineral 500 to 750 seconds viscosity oil, will in general serve the purpose.

Elsewhere it is also perfectly possible to lubricate other stoker bearings with oil and this is often done where it is desirable to use one product for the external bearings of both the prime mover and the stoker. In such cases a medium viscosity engine oil of about 300 sec. viscosity Saybolt at 100 deg. F. will be suitable.

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